U-Net Model for the Identification and Segmentation of the Endocardium in cMR Imaging

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Abstract

Purpose- To use the U-Net Model for the detection and segmentation of the inner endocardial wall of the left ventricle for the calculation of the left ventricular ejection fraction (LVEF) from Cardiac Magnetic Resonance Imaging.

Background- Cardiac Magnetic Resonance Imaging (cMR) is routinely being used to evaluate the structure and function of the heart by quantitative measurements. The left ventricular ejection fraction (LVEF) is one of the most important parameters for LV function. It is an important prognostic indicator of cardiovascular outcomes used clinically to determine the indication for several therapeutic interventions. The accurate segmentation of the left ventricle is an essential step for calculating LVEF.

The current practice at our center is to manually select and delineate the left ventricular inner contour in raw cMR images. This is a time-consuming process and prone to user-induced bias, and hence false positive and false negative results.

Method- The U-Net Deep Learning Model was developed specifically for biomedical segmentation and has proved to work effectively with fewer training samples. Thus, we employed the U-Net Model to perform and evaluate an accurate automatic left ventricle detection and segmentation tool. The U-Net Model has been trained and evaluated on our local clinical data which consists of 4050 short axis images from patients with normal LVEF and normal anatomical structures of the heart. Manual delineations were performed by two experienced radiologists. The performance of the model was evaluated using several statistical parameters namely, accuracy, precision, recall and Intersection over union (IoU).

Results- With a test set of 810 images, the U-Net Model succeeded to detect the presence and the absence of left ventricle in cMR short axis images from all patients. Furthermore, the method achieved high performance of an automatic detection and segmentation of the endocardium with a recall of 91.86%, a precision of 97.16%, an Accuracy of 99.82% and an Intersection over Union (IoU) of 83.65%.

Conclusion- The U-Net Model achieved good performance of left ventricle segmentation with high detection accuracy in less than one minute for each scan. These findings are compelling enough support for conducting a full assessment on a larger patient population.

Keywords: MRI, Cardiac Function, Ejection Fraction, Artificial intelligence, Deep Learning, Neural Network, U-Net Model, Segmentation, Detection.
Limitations: 1. Segmentations were done manually by two radiologists. 2. Limited sample size**.**
Ethics Committee Approval: Yes**.**
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